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Cainozoic History of Mowbray Swamp and Other Areas of North-Western Tasmania

By

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7 PLATES AND 6 TEXT FIGURES

ABSTRACT

The Tertiary limestone succession in the Marrawah area includes a limestone from Green Point which contains basalt boulders and a limestone at Redpa with *Lepidocyclina* correlated with the Batesford Limestone of Victoria. Basalt overlies this limestone sequence disconformably at Mount Cameron West. A basalt at Britton's Swamp contains fragments of Tertiary limestone. Limestone also occurs near Irishtown and, in this area, basalts overly sands and lignite containing *Nothofagus, Triorites harrisii* and *Dacrydiumites*. Basalt occurs above and below "*Turritella* Limestone" at Doctor's Rocks, Wynyard. Lignite from the Launceston Beds near Evandale contains *Trisaccites* which indicates probably an Eocene or Lower Oligocene age and the lignite is overlain by basalt. Faulting at Launceston probably commenced in the Eocene or before. Basalts at Marrawah, Irishtown and Stanley were poured out into the valley tracts of streams. It is doubtful that Mount Cameron West is part of a laccolith, as has been previously suggested, and it is here considered that The Nut at Stanley is a volcanic neck.

Mowbray Swamp is underlain by an Upper Pleistocene marine sand on which rest a number of sand ridges trending E.S.E. In the swales between these ridges peat and sandy peat accumulated more than 37,000 years ago (C14 date). The peat contains the bones of *Nototherium* spp., other giant marsupials and emus, freshwater molluscs and ostracods, as well as pollens of *Banksia, Haloragis* and *Eucalyptus*. Rocky Cape Caves were probably produced as sea caves when the sea was 70 feet higher than at present and at this time the marine sand underlying Mowbray Swamp was deposited. The ancient sand ridges were formed as

sea-level fell from this height. Peat and marl formed in a swamp at Pulbeena and one of the peat samples gave an age of 13,500 years (C14 date). The holotype of *Nototherium tasmanicum* is figured. Tasmanian aboriginal rock carvings occur in Quaternary aeolianite north of Mount Cameron West and their middens occur in the dunes just south of the mountain. Duck River is incised 15 to 20 feet into its channel and is depositing a delta in Duck Bay. There is a series of Holocene sand ridges on Perkins' Island and east of the mouth of the Black River, where eighteen ridges in three sets show a total fall of about 10 feet in sea-level. The Rocky Cape Caves contain deep kitchen middens from which many fish bones and a bone awl were obtained, indicating that the Tasmanian Aborigines ate fish and used bone implements.

Introduction

During May and June of 1952 the authors spent a week in the Smithton area collecting samples for radiocarbon dating and data on the occurrence of *Nototherium* as well as investigating other problems in the Cainozoic history of the north-western part of the State. Later, Gill spent a week in the Queen Victoria Museum examining their collections. Early in 1955, Banks visited the Wynyard and Marrawah areas to check on the ages of some of the basalts.

Acknowledgments

Many people have contributed directly and indirectly to this paper and to some extent the authors have acted as observers and co-ordinators of results from many sources.

Our work in the field was greatly reduced by help generously given by Mrs. E. C. Lovell and family, Mr. F. S. R. Shoobridge and Mr. B. Edwards of Mella. Mr. J. Loveday, C.S.I.R.O. Soils Division, told one of us (M.R.B.) of the probable occurrence of early Tertiary basalt at Wynyard and helped to check this point in the field. Our work at Irishtown was considerably aided by the guidance of Mr. Roy Quilliam. Mr. A. Walker, Smithton, sent specimens of basalt with limestone inclusions from Britton's Swamp to E. D. Gill. In the Evandale area Mr. K. R. von Steiglitz guided us to the spot near Evandale from which "cycad cones" had been collected.

Dr. M. F. Glaessner, Mr. A. C. Collins and Mr. A. N. Carter have all provided identifications of foraminifera collected together with comments on their age or ecology. Miss Hope Macpherson identified the shells in the marl and mound spring deposits at Smithton and in the middens at Rocky Cape; Mr. Gilbert Whitley identified the fish bones from the middens. The wood from the peat in Mowbray Swamp was identified by Mr. H. D. Ingle, C.S.I.R.O., Forest Products Division, and Dr. Isabel Cookson identified the pollens. Dr. A. W. Beasley, National Museum of Victoria, commented on the mineralogy of the marl from Mella and checked observations on the tuff from Circular Head. Mr. P. Garrett and Miss P. Reynolds, Public Library of Victoria, checked on comments in Captain Cook's log on the eating of fish and use of bone implements by aborigines. Mr. G. Baker kindly cut a slide from the Britton's Swamp material. Mr. G. D. Hubble, provided helpful information on soils (see appendix). The work originated with a request from Dr. E. S. Deevey, Director of the Geochronometric Laboratory at Yale University, for material for radiocarbon analysis and he did four analyses recorded herein. To all these people we acknowledge our indebtedness.

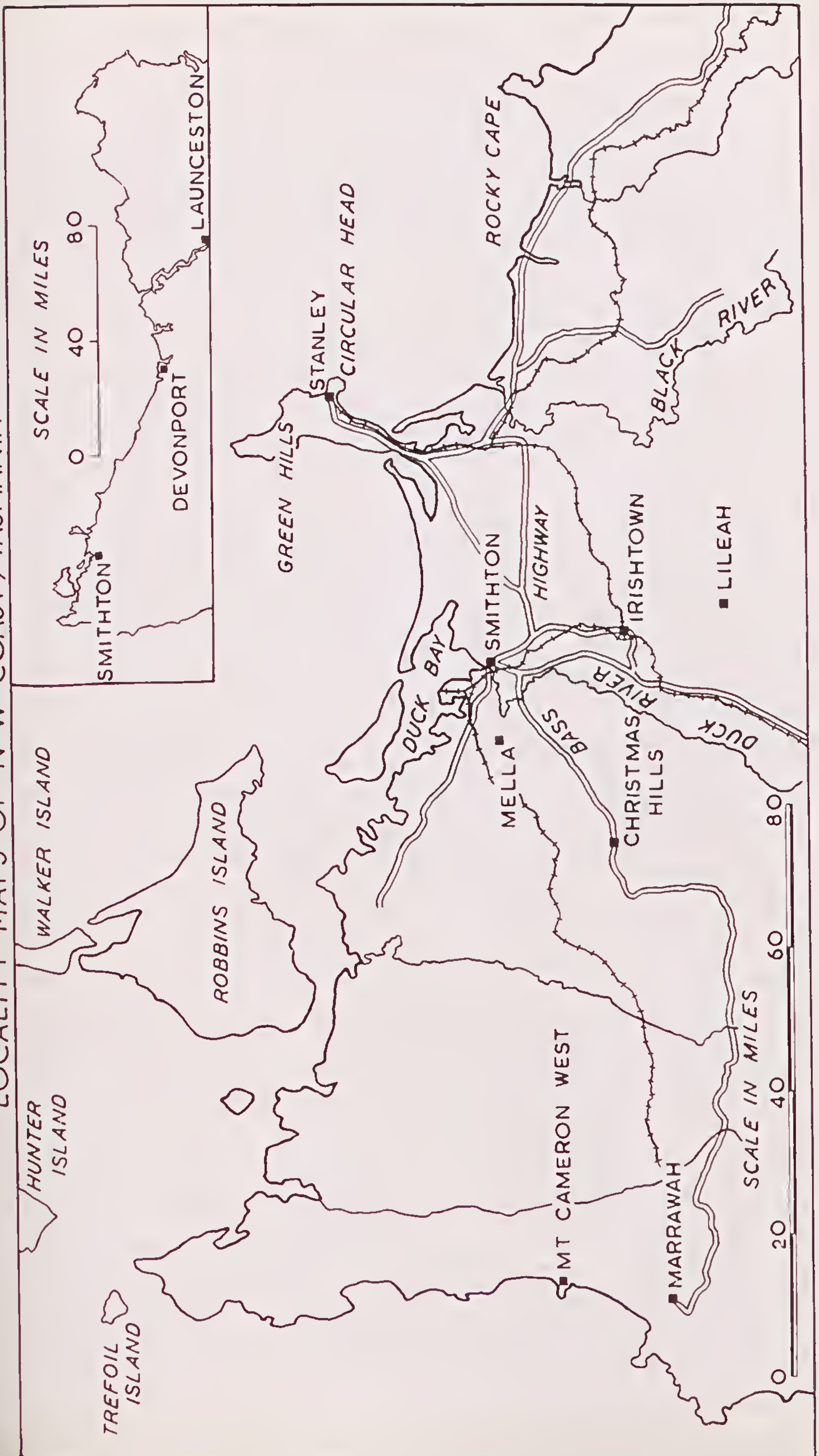

LOCALITY MAPS OF N W COAST, TASMANIA
SCALE IN MILES
0
40
80
SMITHTON
DEVONPORT
LAUNCESTON
HUNTER ISLAND
WALKER ISLAND
ROBBINS ISLAND
TREFOIL ISLAND
GREEN HILLS
STANLEY
CIRCULAR HEAD
ROCKY CAPE
BLACK RIVER
DUCK BAY
SMITHTON
HIGHWAY
IRISHTOWN
LILEAH
BASS
DUCK RIVER
MELLA
CHRISTMAS HILLS
MT CAMERON WEST
MARRAWAH
SCALE IN MILES
0
20
40
60
80

Fig. 1.

We also wish to acknowledge with thanks permission of the Surveyor General to publish the air photos of Rocky Cape, the permission of the Smithton Harbour Trust and the Mowbray Swamp Drainage Board to use and publish parts of their charts. Finally, we would like to thank Mrs. I. Mead, formerly Director of the Queen Victoria Museum, for making available collections and other facilities at the Museum.

Tertiary System

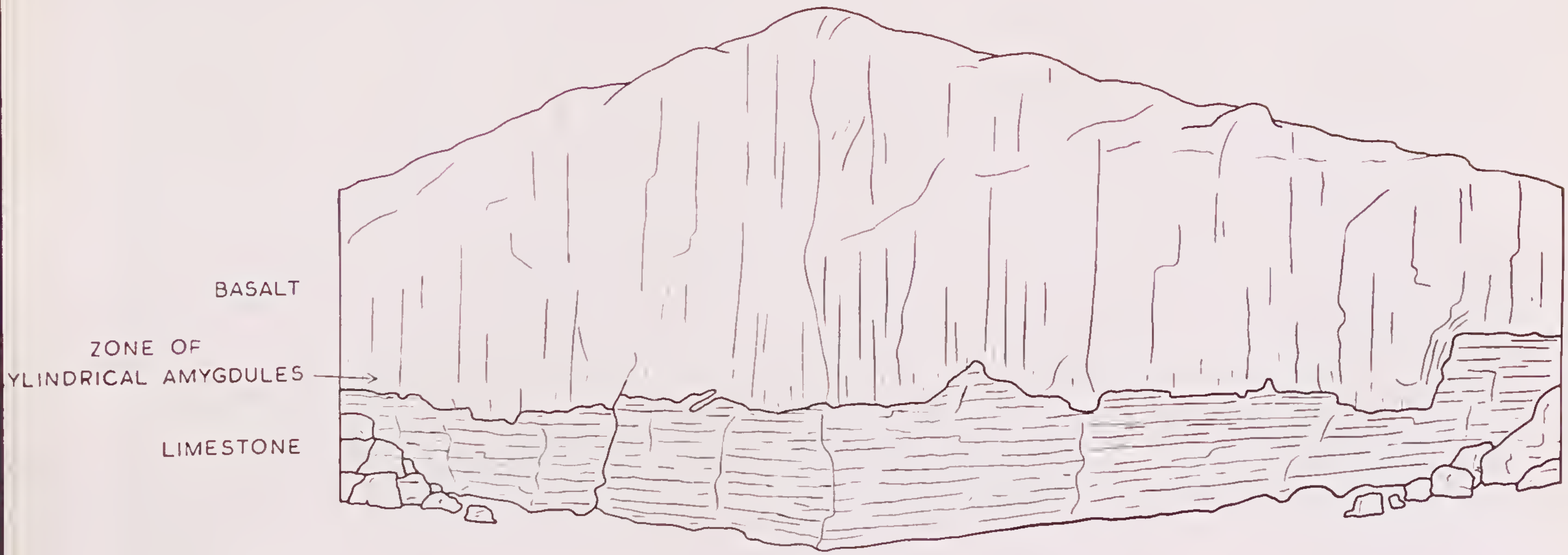
Marrawah

Tertiary limestone is widespread in the Marrawah district as shown by Nye (1941) who considered that at least some of them were younger than the basalts in the district. This was based on evidence of basalt boulders in limestone (Nye and Blake, 1938) and on the impression that the limestone fringed the basalt hills.

In an endeavour to check on this evidence, one of the authors visited the district. In a small quarry 38 chains south-east of the tip of Green Point, on the east side of a road to a farm house, bryozoal limestone was found with several angular fragments of weathered basalt. The basalt showed no sign of epidote, an almost universal constituent of the Cambrian spilites of Tasmania and is probably Tertiary. Petrological work will be necessary to prove this. This limestone is higher than that at Mount Cameron West. The precise age is not yet known but it is probably not younger than Middle Miocene. Thus it is probable that there were pre-Middle Miocene basalts at Marrawah and possibly they were pre-Upper Oligocene.

Several miles south of Redpa, near the western margin of the plain of the Welcome River, Nye (1941, p. 14) recorded a limestone sequence 100 feet thick overlying dolomite unconformably at about 135 feet above sea-level. The sequence is overlain by basalt in the surrounding hills. It has recently been shown to contain a bed of friable foraminiferal limestone with *Lepidocyclina* (*Trybliolepidina*). This is correlated with the Batesford Limestone of Victoria of Lower Miocene age. Details of these observations in the Marrawah area will be published elsewhere, but this summary is provided so that the chronology of the north-west can better be evaluated.

Edwards (1941*b*), described the basalt of Mount Cameron West as a laccolith intruding into "flat-lying (?) Permo-Carboniferous sediments". The strata underlying the basalt were examined on the southern flank of the Mount at and just above sea-level, where they consist of yellow, white and red limestone with flaggy to massive bedding. The rock is friable, consisting almost exclusively of the calcareous remains of marine invertebrates, particularly bryozoa, so is best named a calcarenite, most of the fragments being clastic and of sand grade. Macrofossils include lamellibranchs (*Spondylus*, *Pecten*), brachiopods (*Magellania*) and echinoids. Foraminifera include *Carpentaria rotaliformis* Chapman and Crespin, *Cassidulina subglobosa* Brady, *Cibicides* close to *ungerianus* (d'Orbigny), *Notorotalia* probably *howchini* Chapman, Parr and Collins, and cf. *Pseudogaudryina crespinae* Cushman. Mr. A. C. Collins considered that the most probable age is Balcombian (in the wide sense). Dr. Glaessner also kindly examined a sample and reported, "I consider the fauna as late Oligocene, related to the upper part of the Torquay Group and its equivalent in South Australia. It does not contain the restricted pelagic species of the Lower Miocene Balcombian (*Austrotrillina* Zone) or the Upper Eocene (*Hantkenina* Zone)." Taken together, the reports suggest a Longfordian age, but this needs further investigation. Crespin (1945) has reported



Block Diagram Showing Contact Between Tertiary Limestone and Basalt on South Side of Mt. Cameron West

FIG. 2.

Longfordian limestone from King Island in Bass Strait. A point of interest recorded by Nye (1941, p. 14), is that the base of the limestone south of Redpa is at 135 feet. This seems to indicate that the limestone transgressed over a fairly uneven surface because it extends to below sea-level at Mount Cameron West. Another point of interest is that the limestone is often as high as 250 feet above sea-level. This probably means that the sea was that much higher in the Mid-Tertiary but, until detailed field work is done, the possibility of faults having elevated both base and top cannot be overlooked.

The basalt overlies the limestone with a marked disconformity as can be seen in the cliffs to the south of Mount Cameron West. The disconformity surface is quite irregular and indicates some considerable period of erosion between the deposition of the limestone and the outpouring of the basalt. This surface is shown in the block diagram (text-figure 2). The only effect of the basalt on the limestone is the hardening of the latter to a depth of a few inches. Near the contact the basalt is very fine grained, almost tachylytic in places, and is remarkable for the long cylindrical (pipe) amygdules, generally one quarter to one half of an inch in diameter, filled with calcite, which rise six inches to a foot above the contact. These amygdules attain a maximum diameter of three quarters of an inch; some are simply branched but most are solitary pipes. These indicate that the basalt cooled at the surface of the earth, or very close to it.

The basalt of Mount Cameron West extends in an unbroken ridge eastwards to the main basalt plateau and neither the field occurrence of the basalt, nor its relation to the sediments, requires the postulation of a laccolith, but agrees well with the idea that it is simply a thick flow or series of flows. In the cliff at the south end of Mount Cameron West, moderate columnar jointing can be seen in the basalt, some of the columns being over six feet in estimated diameter. The columns seem to indicate that there was but a single thick flow. It appears likely that Mount Cameron West is a remnant of a dissected flow which originally poured down a valley running approximately west to the position of the Mount. The presence of such a valley seems indicated by the various heights of Tertiary limestone outcrop as recorded by Nye (1941). Thomas (1945) reported that "It is extremely doubtful whether Mount Cameron West is a laccolith, as although the main peak may be considered as a plug, the two small peaks are composed of basalt flows, resting on the denuded flanks of the Miocene limestone." It is very difficult to reconstruct a sufficient cover of Tertiary sediments in the area to halt the upward progress of the basaltic magma in order to produce a laccolith and on this count too it seems likely that the basalt is extrusive.

Observations at Marrawah thus indicate that basalts were possibly erupted before the Upper Oligocene, that limestone was deposited during the Upper Oligocene and Lower Miocene and that these were probably eroded to form valleys up to 200 feet deep before basalt covered them. The upper basalts are therefore younger, possibly considerably younger, than Lower Miocene.

The vertical nature of the cliff at the south end of Mount Cameron West is due to the erosion by the sea of the Tertiary limestone at its base, thus causing collapse of the columns of basalt above. This is not a rapid process however, as there is an aboriginal kitchen midden among the boulders of the talus slope lying against the limestone at the foot of the cliff, and the aborigines have not lived in that area for over 75 years.

Basalt from the north end of Britton's Swamp contains pieces of baked fossiliferous Tertiary limestone, with *Pecten* cf. *antiaustralis*, a piece of pyrite-bearing Palaeozoic sedimentary rock and pieces of opaline silica. The limestone is highly fossiliferous and contains *Carpentaria*, *Triloculina*, *Sigmoilina* and other Miliolid genera. Unfortunately there was insufficient evidence for an age determination and Mr. Carter suggested that ". . . possibly metamorphism destroyed all the small hyaline foraminifera. The association of *Carpentaria* with abundant Miliolids suggests a shallow water deposit." The basalt tends to follow the outlines of the fossils and a bryozoan can be recognized in the basalt which has digested the limestone matrix. This occurrence is of interest in indicating that Tertiary limestone occurs well inland in this district.

Lileah and Irishtown

Thomas (1944) recorded Tertiary limestone from near Irishtown but did not state precisely where.

On the basaltic plateau east of Irishtown (south-east of Smithton), a tunnel, 3 chains long, has been excavated in Tertiary deposits under basalt on R. V. McKay's farm (Smithton, Run 4, No. 30, 809; 6·6 cm. N.W. of C.P.). Three feet of lignite were observed covered by carbonaceous sand then clayey sand. Samples of wood and carbonaceous sand were collected. The former proved on sectioning to be too collapsed for identification. Pollens occur in the carbonaceous sand and include:

Nothofagus (*brassii* type)
Nothofagus sp. *a* (*menziesii* type)
Triorites harrisii Couper (perhaps the most numerous type)
Myrtaceidites parvus anesus Cookson and Pike
Myrtaceidites mesonesus Cookson and Pike
Podocarpus sp.
Dacrydiumites florinii Cookson and Pike
Dacrydiumites mawsonii Cookson
cf. *Polypodium* (fern)
Smooth trilete fern spore.

This Tertiary flora disappeared from S.E. Australia by the end of the Pliocene (Gill, 1952).

At Lileah, in a creek bed south of a house (Aerial photo Smithton Run 2, No. 30,913; 5·4 cm. S.W. of C.P.), lignite occurs, covered by a partly silicified sandstone, which is light yellowish brown to reddish brown in colour due to ferruginization. Some nodules of limonite were noted. Two geochemical processes are represented here which must have taken place at different times because of the different pH conditions involved. It is probable that the silicification took place first and the ferruginization later, during the weathering of the basalt. The lava is very deeply weathered, nine to ten feet of dark red loam being visible in the road cuttings. Its physiographic occurrence and degree of weathering are reminiscent of the Older Basalt of Victoria, New South Wales, and Queensland. The lignite contains milky quartz gravel in places. Wood from this bed proved to have its cells too collapsed for identification and no pollen was found in the sample collected for pollen analysis.

Nye, Finucane and Blake (1934) have shown that the basalt in this area was erupted as four flows to a total thickness of over five hundred feet and that between the flows are deposits of quartzites, gravels, sandstones and clays with one lignitic formation. These authors suggested that presence of a pre-basaltic valley "trending east-north-easterly from the vicinity of the Arthur River, through Trowutta, towards the Stanley Peninsula" where it is probably represented by the basalt of the Green Hills. The existence of this pre-basaltic river was also thought probable by Edwards (1941*a*) who also deduced valleys entering the main

PLATE VII.

FIG. 1.—General view of The Nut, Stanley.

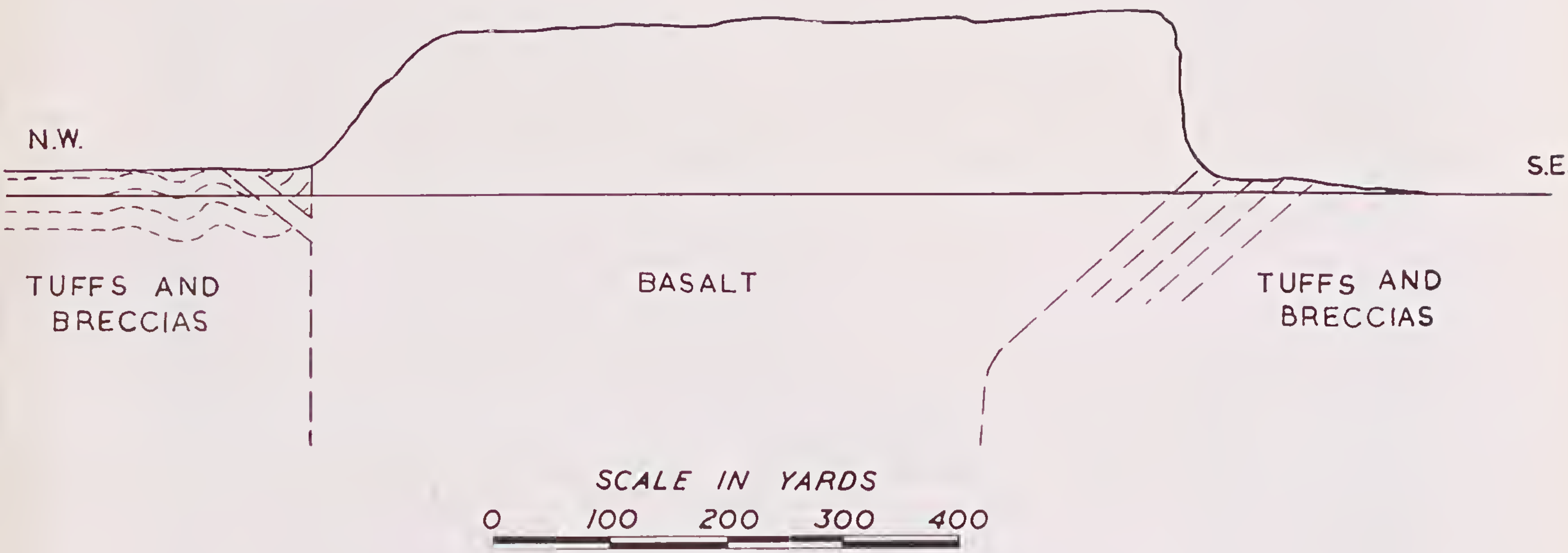
FIG. 2.—Shore platform of basaltic ejectamenta near the Stanley cemetery. Part of The Nut can be seen in the background.

one from the east near Circular Head. The sandstones and conglomerates of the inter-basaltic formations were probably derived from the Bryant Hill Quartzites (Carey and Scott 1952), which would have formed the sides of the fossil valley, the topography covered by the basalt had a low relief with gentle slopes as shown by the relative heights of the base of the basalt. A rough average gives the gradient of the former valley floor from Edith Creek to the sea at Green Hills as 25 feet per mile, while from Edith Creek to Irishtown the grade was about 50 feet per mile.

Circular Head (Plate 7)

Circular Head is a prominent topographic feature of the far North-West coast of Tasmania. It has been described as a erinanite laccolith by Edwards (1941*b*) who wrote, " On the north-western side, on the beach below the Stanley cemetery, the scree overlies soft mudstones and grits which are exposed in the wave-cut bench. These sediments . . . are presumably of Permo-Carboniferous age ". The rocks in the shore platform near the cemetery were examined and also those on the south side of The Nut, in a quarry behind the wharves. According to Edwards, they also outcrop on the northern end of Godfrey's Beach where they are overlain by basalt, but this exposure was not examined. The rocks near the cemetery are volcanic ejectamenta of all sizes from fine tuff to breccia, most being coarse tuff. Brownish in colour and very porous, they seem generally to be rather decomposed. They are finely laminated to massive, although in places the bedding surfaces of the tuffs in contact with the breccias are most irregular. Cross bedding is also present, but insufficient observations were made to determine if this was of aeolian or aqueous origin. The dip of the beds varies from steeply dipping to the north to almost horizontal and in general the dip seems to steepen as the inferred contact with the igneous rock is approached. Detailed mapping will be necessary to show the structure. In the field it appeared that the rock was composed of irregular, angular and subangular fragments of volcanic rock in a finer-grained matrix. Occasional angular fragments of massive and laminated quartzite were also found.

The disintegration of the rock in the laboratory confirmed the observations made in the field. The rock was sufficiently friable to break down after standing in water for a few minutes, after which the sediment was graded and each grade examined separately. All grades were composed dominantly of angular to sub-angular grains and sub-rounded grains were the exception. The coarser grades were composed almost entirely of vesicular and amygdaloidal basalt and tachylyte, while the finer grades were similarly constituted with the addition of fragments of olivine, pyroxene, and the white mineral that fills the amygdules. An independent examination of the heavy minerals by Dr. A. W. Beasley proved the presence of basaltic minerals. Thus, there can be no doubt that the rocks are tuffs and breccias of pyroclastic origin. Fossils were not observed in the brief examination made in the field, nor was any sign of fossils seen in the rocks when studied in the laboratory. Thus the age of the sediments cannot be satisfactorily determined. The authors consider, however, that it is most unlikely to be " Permo-Carboniferous ". The rock is very poorly lithified whereas all Permian rocks seen by the authors in Tasmania are well lithified and require very harsh treatment for their disintegration. On the other hand, the Circular Head rocks resemble closely the tuffs and breccias associated with the Tertiary basalt flows in Tasmania and Victoria, and so the authors prefer to regard them as Tertiary.



SKETCH SECTION THROUGH THE NUT, STANLEY

Fig. 3.

The basic igneous rock intrudes these sediments somewhat irregularly. In the quarry face on the south-east side of The Nut, the contact is concordant and steeply dipping to the north and north-west. On the shore platform to the north of The Nut, several dykes of basalt occur in the sediments being roughly at right angles to the inferred contact between the basalt and the sediments. In several of these dykes the basalt is seen to be vesicular and Edwards (p. 408) pointed out that the basalt just above the contact on the south-east side of The Nut is also vesicular. The vesicularity suggests that the basalt consolidated at the surface, or closer to it than envisaged by Edwards, while the contacts observed and the structure of the sediments as far as seen do not support the idea that The Nut is a laccolith. Rather do they suggest that it is the remnant of a volcanic neck intruded through tuffs, probably of Tertiary age. Further field work and mapping are necessary before this idea can be finally substantiated.

Doctor's Rocks, Wynyard

At Doctor's Rocks, east of Wynyard, a flow of basalt overlies the Permian Wynyard Tillite unconformably and passes below sea-level. This basalt shows no sign of pillow structure at either the lower or upper contact so that from available evidence it would seem to have been poured out onto the land surface. The basalt is overlain by some feet of "*Turritella* Limestone", as developed at Fossil Bluff, Wynyard and where the limestone overlies basalt the basal few inches contain basalt boulders. This limestone is in turn overlain by more basalt. The limestone is Oligocene (Janjukian), so approximately there is a pre-Oligocene basalt and a post-Oligocene basalt. The discovery of the limestone between the basalt flows was made by J. Loveday, C.S.I.R.O. Soils Division, and will be more fully described elsewhere.

Evandale.

Mr. K. R. von Steiglitz kindly conducted us to Rose Rivulet, Evandale, near Launceston. Clays, clayey sands, sand and ironstones outcrop in the banks of the creek. They are Tertiary in age and belong to the palaeogeographical Lake Tamar (Carey 1947). From this site came the specimens considered by H. H. Scott (1931, 1934) to be Cycadophytes. They were collected by Mr. von Steiglitz and Mr. E. O. G. Scott, so we were guided to the locality by one of the original collectors. One of us (E.D.G.) later examined Scott's specimens in detail and could not find justification for this determination, an opinion supported by Dr. Isabel Cookson (1953). Carbonaceous material from this site was kindly ex amined for us by Dr. Cookson, who recognized the following pollen forms:

Nothofagus (*brassii* type)
Nothofagus sp. *c.* Cookson
Nothofagus sp. *g.* Cookson
Banksiaedites spp.
Beaupreaidites verrucosus Cookson
Proteacidites cf. *crassus* Cookson
Proteacidites parvus Cookson type
Myrtaceidites spp.
Myrtaceidites parvus Cookson and Pike type
Microcachrydites antarcticus Cookson and Pike
Podocarpus several types
Dacrydiumites florinii Cookson and Pike
Trisaccites micropterus Cookson and Pike

On present knowledge, the last-named sporomorph is pre-Yallournian in age. In spite of all the work done on the Yallourn brown coals, no *Trisaccites* has yet been found in them, whereas the sporomorph is common in the Eocene brown coals of the Otway Mountains (also in Victoria) which present a similar facies. *Trisaccites* is not known to exist later than the Eocene (or Lower Oligocene at most). It is found in the sub-Older Basalt deposits of the Snowy Mountains and Vegetable Creek in New South Wales, which are probably of similar age (Cookson and Pike 1954).

This dating is very significant, because it allows some of the faulting of the Launceston area to be dated. Carey (1947) showed that the sequence of events in the Launceston area was: dolerite intrusion, peneplanation with lateritization, faulting, deposition of sediments in lakes developed in the fault troughs and then eruption of basalts. Some of the lake sediments can now be dated as Eocene or Lower Oligocene so that the earlier faulting occurred in the Lower Tertiary. Faulting has displaced some of the lake beds, as seen in the excavations for the Trevallyn Power Station and it is likely that faulting continued during deposition. The faulting is not known to have displaced the basalt which overlies the lake sediments probably disconformably and the valley occupied by the basalt near Beauty Point has been cut by the Tamar Valley. The latter can be traced by examination of submarine contours to a depth of 125 feet below sea-level. The erosion of the valley to this depth is thought by Edwards (1941*a*) to have occurred during a period of low sea-level, correlated with the Mindel Glaciation. The basalt then is post-Lower Oligocene and pre-Middle Pleistocene. No closer estimate can yet be made. Cotton (1949, p. 293) doubted the antiquity of the faulting around the Launceston trough on geomorphological grounds and tended toward an Upper Tertiary age for them. If the argument based on *Trisaccites* is correct, however, much of the faulting must be Lower Tertiary, even older than the Lower Miocene age postulated by Carey (1947) and criticised by Cotton. The possibility of Upper Tertiary faulting cannot yet be ruled out but it is remote. The main scarp-forming faulting is probably Eocene in age.

Summary of Observations on the Tertiary System

In the Lower Tertiary (Lower Oligocene or before) faulting commenced to disrupt a lateralized peneplain in the Launceston area. Gravels, sands, clays and lignite with *Trisaccites* were deposited in a fault trough, with faulting continuing during deposition. The climate was apparently pluvial and perhaps warmer than at present. In the Wynyard districts basalt was poured out, probably before the Upper Oligocene, on to a land surface extending below present sea-level and basalt was possibly erupted in the Marrawah district before the Upper Oligocene. At Wynyard, the Lower Tertiary basalt was covered by marine Lower Miocene limestone and at Marrawah by marine limestones of Upper Oligocene to Lower or perhaps Middle Miocene age. Similar limestones to those at Marrawah occur also at Temma, Britton's Swamp and Irishtown up to heights of 250 feet above sea-level, probably marking extensive marine transgressions in the Miocene. Later the sea retreated to below its present level, the limestones were eroded to produce fairly wide valleys several hundreds of feet deep. Sands, gravels and lignites accumulated in these valleys as in the Lileah and Irishtown area. The limestones were deposited in a sea warmer than at present (as shown by the presence of *Lepidocyclina*) and the lignites indicate a pluvial climate, probably a little warmer than at present. Basalt flowed down these valleys cut in the limestone to below present sea-level. This seems to be the case at Marrawah, Britton's Swamp and Montagu, Irishtown and Circular Head and Wynyard. There were apparently many eruptions of lava as Nye et al. (1934) recorded at least four, separated by sands and lignite at Irishtown, and the basalt of Green Hills flowed down a valley system cut in tuff from earlier eruptions. The volcanic neck of The Nut is later than the tuffs but its relationship to the flows of Green Hills is unknown. The age of the basalts at Launceston is not known with certainty but the limits are Lower Oligocene and Middle Pleistocene.

QUATERNARY SYSTEM

PLEISTOCENE SERIES:

Christmas Hills

The road from Smithton to Marrawah passes over a slightly higher and much more sandy area of the Mowbray Swamp as it approaches the Christmas Hills. Where the road ascends from the Swamp to the higher country, cuttings reveal a formation of fine white sand. An instructive section can be seen in a quarry on a prominent bend one to three chains east of Marrawah 26 milepost (Aerial photo Smithton run 5, No. 30,786).

The sequence is as follows:

Top	1 ft. mid-grey soil
	10 ft. white sand (mostly clear quartz)
Bottom	6 ft. plus of dark-brown carbonaceous sand.

The sand is very fine, well rounded, and well sorted. Both the white sand and the carbonaceous sand are cross-bedded (Plate 4, figs. 1-2), the latter having a persistent dip of 27° West and a meridional strike. The nature of the sand and the cross-bedding indicate that the materials were windblown. The carbonaceous sand lenses out at the east end of the quarry, but is still well developed where the outcrop is cut off at the west end 1½ chains away. It occurs also in the gutter of the road. Further up the hill, white sand occurs over the red clay which characterizes the plateau above. The red clay is derived from rocks of basaltic type.

Three periods of differing recent climatic conditions are suggested by the sands on the flanks of the Christmas Hills, viz.—

Pluvial	Formation of carbonaceous sand as seen in bottom of quarry.	Carbon rich.
Drier	Formation of white sand deposit.	Carbon poor.
Pluvial	Formation of present carbonaceous soil and thick forest growth.	Carbon rich.

Mr. G. D. Hubble, C.S.I.R.O. Division of Soils, has drawn our attention to the possibility that this section (and the one at Chequers Drain) is a giant podsol and not a series of layers produced by different climatic conditions.

The present average rainfall of the area varies at different localities from 34·92 ins. to 57·39 ins. per annum, the higher falls occuring in the higher parts of the country. Dr. Isabel Cookson examined the carbonaceous sand from the bottom of the quarry, and found the following pollen and spores:

Myrtaceae
? *Podocarpus alpinus*
Compositae
Gramineae
cf. *Gleichenia*.

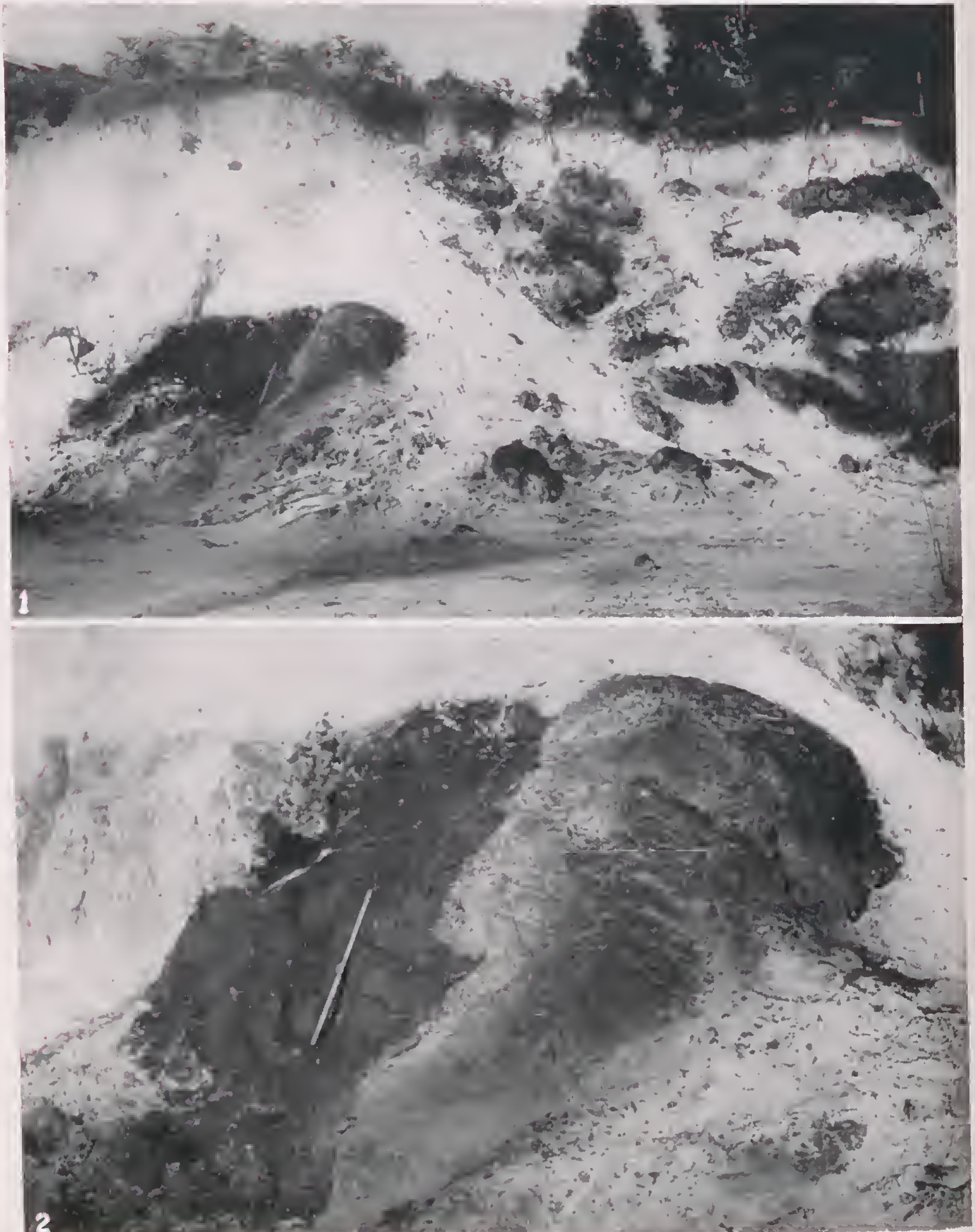
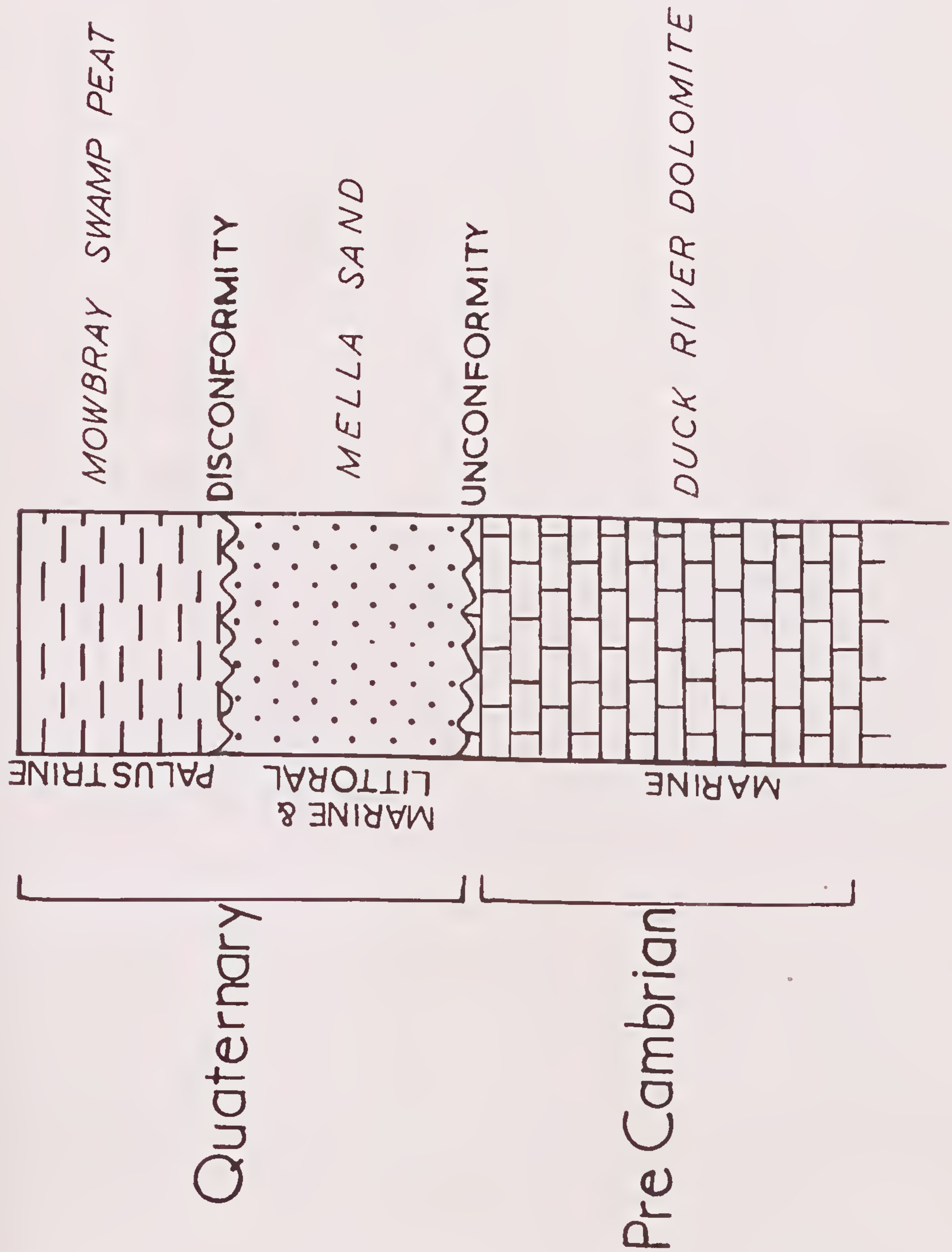


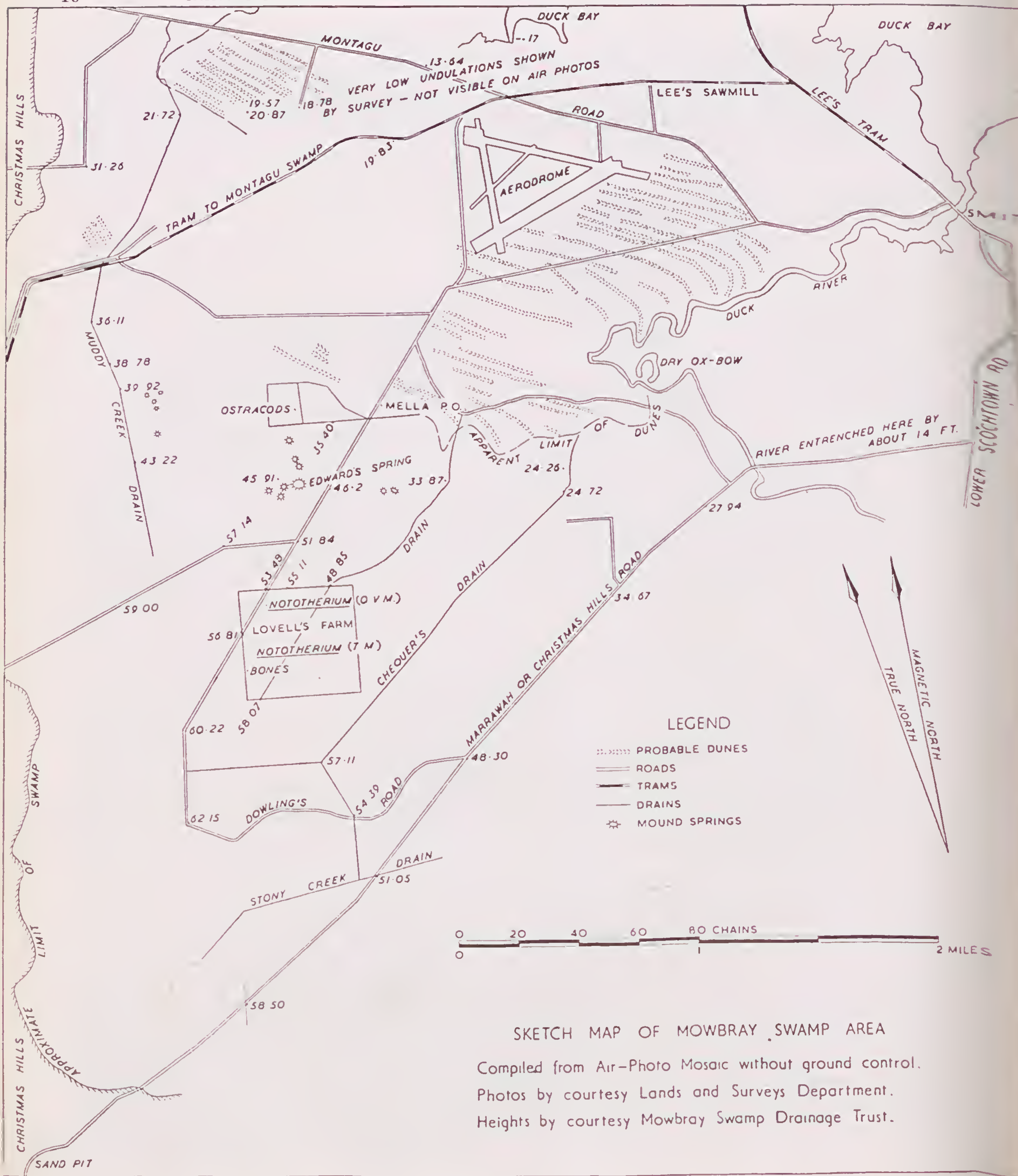
PLATE IV.

FIG. 1.—Quarry on south side of Marrawah Road at Christmas Hills.
FIG. 2.—Closer view of the polleniferous carbonaceous sand.

Nye, Finucane and Blake (1934) and Edwards (1941*a*) have commented on the sand deposits of the Christmas Hills in relation to the Duck River Plain. Our observations support the view that the present level of the plain is more or less the original one.

FIG. 4.





SKETCH MAP OF MOWBRAY SWAMP AREA

Compiled from Air-Photo Mosaic without ground control.
Photos by courtesy Lands and Surveys Department.
Heights by courtesy Mowbray Swamp Drainage Trust.

Mowbray Swamp

South and west of the town of Smithton is a lowland some six miles wide and extending twelve miles inland. On the east it is bordered by land of the order of 200 feet above the sea, consisting of folded Cambrian spilite and Precambrian silicified sandstones covered on the seaward part by sands and further inland by Tertiary basalt (Carey and Scott 1952). On the west, the lowland is bordered by similar high ground underlain by ?Cambrian argillite, greywacke and breccia, as may be seen, for example, in a quarry on the Montagu Road and by the coastal outcrops at Stony Point. The eastern side of the lowland is underlain by Precambrian dolomite, but what underlies the main part of the Mowbray Swamp is not known. The lowest bed of the Pleistocene Series so far found beneath the Mowbray Swamp is a sand—here called the Mella Sand and defined as a formation of sand of unknown thickness underlying the Mowbray Swamp Peat, exposed at Lovell's Farm, Mella. Nye, Finucane and Blake (1934) reported marine mollusca from Mowbray Swamp, probably from the Mella Sand. In the National Museum of Victoria, Melbourne, there is a collection made from Mowbray Swamp by Mr. L. R. East, consisting of the following:

Cardium racketti Donovan; a sand dweller, and still common along the coast;
Ostraca sinuata Lamarck; the rock oyster;
Panopea australis Sowerby; a mud dweller;
Mimachlamys asperrimus (Lamarck); a deep-water dweller.

These shells represent a mixture of facies, and so must have been washed together at their place of fossilization. On the farm of Mr. F. S. R. Shoobridge, in a drain 370 yards north-west of the Mella Road, opposite the Mella Post Office (see text-figure 5), casts of *Cardium* were found in peaty sand dug from the bottom of the drain about four feet from the surface. Reports of a number of other occurrences of sea-shells under the peat were received, but the shells were not seen. No evidence was seen of Pleistocene marine sediments on the high country east and west of the lowland. The sand constituting this formation may have been derived from the breakdown of the Precambrian Bryant Hill Quartzite as can be seen clearly in the White Hills, south-east of Smithton. A quarry south of the highway shows the rock to be leached for ten to twenty feet from the surface, freeing the sand; so much so that the ridge looks like a sand dune. This hill is not within the present drainage area of the Duck River, however, and if the present eastward set in Bass Strait was operative at the time of the high sea-level when this formation was deposited, sand from White Hills could not have been deposited in the former Duck Bay.

The marine part of the Mella Sand is overlain by a number of sand ridges, now occurring at Lovell's Farm House, Mella, and at other places in Mowbray Swamp as shown on the map, figure 5. The ridges are now low sand rises spaced 80 to 100 yards apart and trending in an E.S.E. direction probably parallel with the former shore lines. The ridges become progressively lower in elevation above the sea as the present shore line is approached. Mowbray Swamp is highest in the south-west where sand is accumulated in the lowland, and on the sides of the Christmas Hills. The ground here is about 64 feet above H.W.M. (as shown on the Drainage Board Map) but there may be a small depth of sand accumulated by wind action at the foot of Christmas Hills.

The most interesting formation is the Mowbray Swamp Peat. This is a formation of peat and some intercalated marl, usually less than 7 feet thick but exceptionally over 15 feet thick, developed over most of Mowbray Swamp area, and containing fossils including *Nototherium*, *Palorchestes*, *Limnicythere*, &c. It is Upper Pleistocene in age.

Drain sections and ten spade and auger holes in the Mella District and south of Smithton proved peat from 1′ 6″ to 7′ deep. The only exception noted was a comparatively large cutting in the Chequer's Drain S.S.W. of Smithton (text figure 2; aerial photo Smithton run 7, no. 30,661, 6 cm. N. of centre point). The drain cuts through a ridge into the Duck River, and reveals:

> Thin soil at surface with *Eucalyptus* and tea-tree;
> 4-5 ft. fairly loose white siliceous sand;
> 8 ft. 6 ins. compact carbonaceous sand measured to water level: the top of this bed is horizontal;
> Seven ft. more of this bed was proved by auger, but further penetration was impossible owing to the compactness of the rock.

This carbonaceous bed is therefore at least 15 ft. 6 ins. thick; it is not stratified, but has horizontal depositional structures. The succesion here is a loose white sand overlying a compact carbonaceous sand, which is the same succession seen in the Christmas Hills (p. 13). The peat and peaty sand are found in the swales of the ancient sand ridges as shown by auger hole sections in different parts of the swamps such as are recorded a little later when dealing with the *Nototherium* occurrences.

The peat contains a rich fauna and some pollens and the species known to be present are listed below. Where they have been previously recorded, the literature references are given.

MAMMALIA

Nototherium tasmanicum Scott	Scott 1911, 1915, 1927, Scott and Harrisson 1911, Scott and Lord 1921*b*, 1922, 1923, 1924, 1925*a*, *b*, 1926, Noetling 1912*a*.
Nototherium mitchelli Owen	Scott and Lord 1921*a*, *b*, *c*, 1923, 1925*a*, *b*, Scott 1927.
Palorchestes cf. *azeal* Owen	Scott 1916, Scott and Lord 1925*b*.
Phascolonus sp.	Scott and Lord 1925*b*.
Vombatus sp.	
Kangaroo	
Wallabies	
Rodent	

AVES

Dromaius diemensis Le Souef	Scott 1932.

ARTHROPODA	*Candona lutea* King	Chapman 1914.
	Candonocypris candonoides (King)	Determined by N. de B. Hornibrook.
	Darwinula sp.	Deevey 1955.
	Limnicythere mowbrayensis Chapman	Chapman 1914.
MOLLUSCA	*Amphipeplea subaquatilis neglecta* Petterd	Chapman 1914.
	Assiminea tasmanica Woods	Chapman 1914.
	Bulimus dufresnii Leach (= *Caryodes dufresnii*)	Noetling 1912*a*.
	Bulimus tasmanicus Woods (= *Lenameria attenuata* (Sowerby))	Chapman 1914 ?
	Bythinella nigra (Quoy and Gaimard) (= *Austropyrgus nigrus*)	Noetling 1912*a*, Chapman 1914.
	Helix hamiltoni Cox (= *Stenacapha hamiltoni*)	Noetling 1912*a*.
	Pisidium tasmanicum Woods (= *Australpeca tasmanica*)	Noetling 1912*a*, Chapman 1914.
	Simlimnaea (formerly *limnaea*) *gunnii* (Tate)	
	Sphaerium tasmanicum Woods	Noetling 1912*a*, Chapman 1914.
	Succinea australis Ferussac (= *Austrosuccinea australis*)	Noetling 1912*a*.
	Vitrina milligani Pfeiffer (= *Melavitrina milligani*)	Noetling 1912*a*, Chapman 1914, Iredale 1933.

PLANTAE

Dr. Isabel Cookson kindly made pollen analyses of samples from Mowbray Swamp and a sample of peat from between two and three feet at the radiocarbon sample site, near the locality which yielded the type specimen of *Nototherium tasmanicum* (Plates 1-2), four to five chains east of Lovell's farm house, Mella (text figure 5, loc. 2), gave the following results:

Eucalyptus sp.
Gramineae
Compositae, cf. Heliantheae
Other types not identified.
(Pollen content low).

Nototherium and Tasmania

Diprotodon, the largest marsupial known, has been found all over the Australian mainland but it did not reach Tasmania, as far as is known. It did reach King Island, however, which is in Bass Strait between the mainland and Tasmania (Keble 1945), apparently at the time of a eustatic low sea level in the Upper Pleistocene. In Tasmania itself there lived *Nototherium mitchelli* which is found also in King Island and in Victoria, but in addition there was in Tasmania the indigenous species *N. tasmanicum*. In the island of New Guinea there was likewise an indigenous species *N. watutense* (Anderson 1936, 1937). The nototheres are an ancient group going back at least to the Miocene (Gill 1953*b*), but all the above species are believed to be Pleistocene. So far, giant marsupials have been found only in the northern part of Tasmania.

Nototherium tasmanicum. Precise localities have not been published for the fossils of this species recorded from the Mowbray Swamp, but the writers were able to find local residents who witnessed the collection of certain specimens and could show exactly whence they came. The almost complete holotype skeleton (Plates 1-2) in the Queen Victoria Museum at Launceston (reg. no. 1760) with only the feet and a few other bones missing, came from Mr. E. C. Lovell's farm at Mella, 110 yards a little north of east of the house (Aerial photo 30,663, Smithton run 7, 3·9 cm. 8° N. of W. of C.P.). Mr. Lovell found the skeleton at a depth of five to six feet and excavated it himself. The locality is a T-shaped drain intersection. A spade excavation was made in the paddock beside this site to avoid the roots of trees lining the drain and peat was obtained from between 2 and 3 feet from the surface for radiocarbon analysis. Whitish sand was met at a depth of four feet (see text figure 5 for these sites). The surface of the ground here is approximately 55 feet above H.W.M. as estimated from the Drainage Board map. At the waterhole nearby (same aerial photo 3·3 cm. 6° N. of W. of C.P.), peat followed by sandy peat reaches a depth of seven feet. On the other hand, the Lovell home is on a sandy rise.

A less complete skeleton of *Nototherium mitchelli* was located by Mr. Lovell about a quarter of a mile S.S.W. of the Lovell home (locality 4; same aerial photo, 5 cm. S. of W. of C.P.). Mr. Lovell left this fossil for Mr. H. H. Scott of the Queen Victoria Museum to excavate. It is now in the Tasmanian Museum, Hobart. The drain from which this *Nototherium* came was six feet deep when excavated. Members of the Lovell family there at the time of the finding of the fossils, told us that all the fossil marsupial bones found on their property came from the *bottom* of the peat. In the Queen Victoria Museum is a piece of sandy peat "extracted from the brain case of *Nototherium tasmanicum*." The sand is a very fine well-rounded clear quartz sand. The peat nearer the surface has much less sand than this specimen. A few bones of *Nototherium tasmanicum* were found at

yet another locality on Lovell's farm, on the west boundary of the property at the intersection of two drains about 22 chains from the house (same aerial photo, 5·7 cm. 20° S. of W. of C.P.). The drain here was originally about seven feet deep and an auger hole sunk by the authors proved 6 ft. 3 ins. of peat and peaty sand. The surface of the ground here is calculated from the Drainage Board map to be about 56 feet above H.W.M. Mr. K. M. Harrisson obtained the bones from this site. A mutilated femur is now in the Tasmanian Museum, Hobart, while in the Queen Victoria Museum, Launceston, are three teeth (reg. no. 1763). A note by Mr. Scott in the Museum Register says that he re-excavated the site in September 1915, but found no further bones. Other nototherian remains in the Queen Victoria Museum are:

1. Two rami and tusks obtained from Mr. K. M. Harrisson in April 1924. See Scott and Lord 1925*b*.
2. Left cheek teeth and a coronoid process of a young *Nototherium*. Also other cheek teeth and tusks. Obtained from Mr. E. W. Reeman in 1924. See Scott and Lord 1925*b*.
3. " Two upper jaws and a box of various fragments " obtained from Mr. Burnley 14/3/49.

All the nototherian bones found in the Mowbray Swamp (apart from those in the mound springs) are various shades of brownish grey and grey, being stained presumably by the peat and probably such iron as is present being chemically reduced by the decomposing vegetable matter. That calcareous shells are preserved in excellent condition in some places, but dissolved by acids in others, shows a considerable range in pH conditions.

Articulated holotype skeleton of Nototherium tasmanicum. The articulated skeleton of *Nototherium mitchelli* obtained from Mowbray Swamp in 1920 and exhibited in the Tasmanian Museum, Hobart, has been figured, but not the more complete articulated skeleton in the Queen Victoria Museum, Launceston, which is the holotype of *Nototherium tasmanicum*. This is, therefore, now figured in Plates 1 and 2. The head is large, and remarkable for its strong nasal protuberance. *Diprotodon* has a similar protuberance, but not so strongly developed. The zygomatic arch is very strong and is sub-parallel to the main part of the cranium and not bowed. Like those in *Diprotodon* also are the curious scapulae and the rather flat humeri and femora. The tail is incomplete, but it can be seen that it was broad, flat, and rapidly tapering. The hind legs are markedly stronger than the forelegs and the pelvic girdle very powerful in build (cf. *Megatherium*). The animal apparently had the power of rising on its hind legs and this would increase the availability of food in the eucalypt forest of which the pollen analysis provides evidence. *Nototherium* was probably a browser rather than a grazer. Food would be plucked with the conical curved tusks and ground by the heavy molars. Such foot bones as are available show the animal was plantigrade. The feet are weak, as in *Diprotodon*, indicating a tendency for the foot bones to diminish and a pillar type leg to develop, as in the elephant. The skeleton of *Nototherium tasmanicum* and the other vertebrate fossils named in this paper need detailed study and taxonomic revision.

Palorchestes cf. *azael* was found by T. Edwards " in a drain in the Mowbray Swamp " and was acquired by Mr. H. H. Scott of the Queen Victoria Museum, who made this note; " Premaxillaries found by me, also zygoma, occiput, and scraps . . . During my visit to Smithton in 1915, I dug out the grave, with

Edwards, and found the nasals, incisor tooth, an occipital condyle, and other scraps." Scott (1916) described and figured a right upper maxillary with cheek teeth. He states that some nototherian teeth were also found by Mr. Edwards.

Phascolonus. The giant wombat is represented in Mowbray Swamp fauna by the shaft of a femur (reg. no. 1771) received by the Queen Victoria Museum on 8/10/12. It was represented by Hon. E. Mulcahy, M.L.C., and was found on "Wilson's Section". The records in the Museum also mention part of a zygoma. In 1934 a leg bone of a giant wombat from Mowbray Swamp was received through Mr. T. Edwards.

Vombatus. In 1944 a small wombat jaw preserved in lithified cave earth was received by the Queen Victoria Museum through "Mr. T. E. Burns, from cave, Smithton." It is inferred that this fossil is not from the swamp area, but from the higher ground bordering the swamp to the east.

Large Kangaroos, &c. Mr. H. H. Scott registered as number 1766 in the Queen Victoria Museum, the shaft of a femur "regarded as being *Sthenurus* or *Procoptodon*, found at Mowbray Swamp, Smithton, by Mr. F. V. Brumby . . . in 1915 . . . The central muscular tract is very large, but the rest of the evidence is in favour of immaturity. This is a lusty growing animal minus the super-ossification of the adult." Another parcel contained "parts of three wallabies, toe of a large kangaroo and bones of a small rodent, all per Mr. T. Edwards of Mowbray Swamp (with emu bones) 14th. Oct., 1924. All found in a waterblow." This group of bones is medium reddish-brown and lightly mineralized. They are oxidized, whereas those from the peat are always chemically reduced.

"*Dromaius diemenensis* Le Souef". In 1924 Mr. T. Edwards found a femur, two tarso-metatarsi, a cervical vertebra, and synsacrum of an emu in the Mowbray Swamp (reg. no. 1488). The preservation is similar to that of the *Nototherium* bones, viz. of dark colour, and with little if any mineralization. In crevices of the synsacrum some peaty material was noted containing fragments of freshwater shells. A fossil emu was discovered also during the draining operations at Irishtown in 1920 by Mr. E. H. Fenton (Scott 1924). The extinct Tasmanian emu was still in existence when white people arrived (Gunn 1853, Walker 1898, p. 22), but by 1832 it was extinct in the Derwent Valley (Backhouse 1843, pp. 30, 212). Scott (1932) recorded a fossil emu from Mole Creek in Northern Tasmania, west of Launceston. Near Mole Creek is Emu Plain, presumably named after those birds.

There are differences of opinion concerning what the taxonomic standing of the Tasmanian emu should be, i.e., whether it should constitute a species, a sub-species, or just a race. The R.A.O.U. Checklist (1926) makes the King Island emu a full species and the Tasmanian emus a variety of the mainland form. It might be anticipated that, if the emus on King Island between Victoria and Tasmania were isolated long enough to evolve a new species, the Tasmanian emus would likewise evolve and not remain a variety of the mainland species. Mathews (1910) provided interesting information on the Tasmanian emu and has more recently (1946) given its taxonomic standing as *Dromiceius novaehollandiae diemenensis* Le Souef.

On Mr. Shoobridge's farm at Mella (locality 7, Aerial photo 30,663, Smithton Run 7, about 9·2 cm. 6° W. of N. of C.P.) there is a somewhat circular patch

PLATE II.—Nototherium tasmanicum Scott. Holotype from Mowbray Swamp and now in the Queen Victoria Museum, Launceston. Hind view.

of marl not exceeding eight chains in diameter. A spade hole put down by the writers proved the following succession:

2 ft. peat
2 ft. marl (rich in mollusca and with some ostracoda)
2 ft. peat
White sand of unknown depth.

Hydrogen sulphide was detected during the excavation. From the marl Miss Hope Macpherson kindly determined for us the following mollusca:

Australpera tasmanica (T. Woods)
Austropyrgus nigra (Quoy and Gaimard)
Lenameria attenuata (Sowerby)
Melavitrina milligani (Pfeiffer)
Simlimnaea gunni (Tate).

Melavitrina is a carnivorous land snail, so was probably washed into the pond or small lake at Mella. The marl has been dated as older than 37,600 years.

On the east side of the marl lenticle is an elongate patch of clay which seems to represent the bed of an incipient creek. The marl collected is similar to that of the Pulbeena Swamp, but no detailed work has been done on it yet. Analysis of a sample from Mella by Dr. A. W. Beasley gave:

Carbonates	92 per cent
Organic matter	3·3 per cent
Mineral matter	4·7 per cent.

The last-named consisted chiefly of well-rounded and sorted, very small grains of clear quartz, but some feldspar, muscovite, black iron ore, and other minerals were also present.

The same or similar ostracods to those found in Mowbray Swamp are found in the Tootgarook or Boneo Swamp in Victoria (Chapman 1919, Keble 1950, Gill 1953*d*) and in the Pyramid Valley Swamp in the South Island of New Zealand (Duff 1949, Hornibrook 1955, Deevey 1955). This distribution may well be due to birds. Cleland (1952) has shown how widely plants are distributed by birds in Australia and the same could well apply to ostracods. The Double Banded Dotterel (*Charadrius bicinctus* Jardine and Selby 1827) migrates between Australia and New Zealand (Stead 1932, Buddle 1951) and it may be responsible for the distribution of these arthropods. However, it is curious that the diatom florae as reported for New Zealand and S.E. Australia are not more alike.

Surface features in the Mowbray Swamp of considerable geological interest and pedological importance (see addendum on soils) are the spring mounds, or " blows " as they are called locally. These have been referred to by Noetling (1912*a*) and Nye, Finucane and Blake (1934), while Stephens (1913) has discussed the springs in the vicinity of Deep Creek. The sites of some of the mounds are shown in text-figure 5. They are usually between 10 and 20 feet high, with a low angle profile commonly between 5° and 10°. A typical well-developed mound spring is that on the farm of Mr. Ben Edwards at Mella (Aerial photo 30,663, Smithton run 7, 7·1 cm. 11° W. of N. of C.P.). Water used to issue from the top of the mound, causing swampy conditions round it, so a channel was cut in the north side to divert the water into a drain. The water is highly mineralized, issues at the rate of 600 gallons per minute (figure supplied by Mr. Edwards) and maintains a consistent temperature throughout the year of 66°F. Some of the water is utilized in a cowshed built on top of the mound (Plate 3, figure 2). The following section of the mound results from observations to a depth of 7 ft. 6 ins. in the channel draining the mound and this was continued down by auger to a depth of 11 ft. 3 ins. The beds have a low outward dip of approximately 3°.

PLATE III.

FIG. 1.—Aerial photo of Holocene sand ridges near the Black River. The road is the Bass Highway. Published by permission of the Surveyor General, Hobart.

FIG. 2.—Mound spring on Edward's farm at Mella. Near the shed on the left is the section described on page 25.

Surface.	3 ft. 0 ins.	Light-brown soil and "travertine"
	6 ins.	Light-grey calcareous layer with shells
	1 in.	Black peat
	2 ins.	Calcareous layer as above
	6 ins.	Black peat
	9 ins.	Light-grey calcareous layer
	6 ins.	Black peat
	½ in.	Whitish shell layer
	9 ins.	Black peat
	½ in.	Whitish shell layer
	7 ins.	Black peat
	7 ins.	Shelly peat (bottom of channel)
	8 ins.	Black peat with wood
	8 ins.	Whitish to cream shell layer
	8 ins.	Light-grey marly sand
	6 ins.	Creamy calcareous layer
	6 ins.	Dark brownish grey marl with shells
	9 ins.	Light-grey marl of calcareous material and shells
	11 ft. 3 ins.	Total depth.

From our observations, and the reports of farmers, it would appear that alternations of peat and calcareous matter are typical of the Mowbray Swamp spring mounds. The shells are small snail shells such as have been recorded by Noetling (1912*a*) and Chapman (1914) from the marly layers of the Swamp. The marl is often rich in a calcareous alga. We were informed that from this and other mounds on the property, marsupial bones had been recovered. The property was formerly owned by Mr. Burnley and it is noted that Scott and Lord (1924) recorded a mutilated *Nototherium* femur from Mr. Burnley's farm on the Mowbray Swamp. The register at the Queen Victoria Museum records that on 14/3/39 two upper jaws of *Nototherium* and various fragments were obtained "from Mr. Burnley, Smithton". Dr. Cookson noted *Banksia* sp., cf. *Gunnera* sp., *Haloragis* sp., cf. *Hypolaena*, Compositae cf. Heliantheae, Chenopodiaceae and Gramineae pollens from a peat sample from the mound spring section on Mr. Ben Edward's farm at Mella. She did not find coniferous or fern pollens.

The age of Mowbray Swamp was given by Noetling (1914) and David and Browne (1950, p. 616) as Holocene. The present investigation shows that the Duck Bay Sand must have been deposited when the sea was about 70 feet higher than at present when the Rocky Cape Caves (see later) were being cut, or as it retreated. A sea-level at this height is elsewhere dated as Upper Pleistocene, so that this would be the maximum age for the Duck Bay Sand. The fossil shells found in the sand up to 50 feet above present sea-level are all living species and provide no accurate dating. However, all the sand ridges on the swamp antedate the present set which began to form when the sea-level retreated from a stand ten feet above that at present. Thus the Duck Bay Sand and Mowbray Swamp Peat are Upper Pleistocene, not Holocene. This conclusion is in keeping with radiocarbon datings received since the larger part of the paper was written, viz.—

Marl from 2 feet below surface, Shoobridge's farm, Mella (p. 25) $>$ 37,760 years

Peat from 2 to 4 feet below surface, Lovell's farm, Mella (site of holotype of *Nototherium tasmanicum*) $>$ 37,760 years.

These radiocarbon dates also indicate an Upper Pleistocene, not Holocene age.

Three lines of evidence combine to provide a picture of the conditions obtaining when the Mowbray Swamp was being formed:

1. It has already been noted that the peat was laid down chiefly in swales between ancient sand ridges and that the fossil vertebrates were generally found at the *base* of the peat. The evidence of the fossil vertebrates may therefore be taken to apply particularly to the earlier part of the period of peat formation. The fauna included herds of giants like *Nototherium*, *Palorchestes*, and *Phascolonus;* emus were also present. These mammals and birds could not possibly live in the jungle found on the Mowbray Swamp before it was cleared. We are informed by people who helped open up the district that no ground vertebrates were living there when white men came. The giant marsupials would need a good supply of vegetation for food but also space in which to move their huge bodies freely. Moreover, *Palorchestes* was a grassland type of kangaroo (Gregory, 1951, pl. 181) and would need at least an open forest type of environment. The same ecological argument applies to the emus.
2. Calcareous layers rich in freshwater molluscs, ostracods and algae occur as lenses in the peat. The evidence from these beds therefore applies particularly to the *middle* of the period of peat formation. These beds were packed with dense plant growth when in their natural condition just before clearing but at the time of their formation they must have been open sheets of water. For example, two feet thickness of 92 per cent calcium carbonate, free of peat, could not accumulate except under open water conditions. Some of the mollusca are lacustrine species. Ready access of light was necessary to grow algae and to provide the food for the ostracods and molluscs.
3. The palynological evidence is derived from peat about half way through the available thickness on Lovell's farm at Mella (loc. 2) and the peat of the mound spring deposit on Edward's farm at Mella (loc. 6) and so applies chiefly to the *middle and later* parts of the period of peat formation. In that the pollen grains are of Myrtaceae, *Banksia*, grasses, chenopods, composites and such like, an open forest association is indicated. Probably *Nototherium* browsed on the Myrtaceae chiefly, while *Palorchestes* grazed mainly on the grasses.

Thus, all three lines of evidence indicate a climate damp enough to cause peat formation, to form small lakes and to provide a flora rich enough to meet the needs of the herds of giant marsupials. On the other hand, it was dry enough to develop an open forest (not a wet forest) and so contrasts with the conditions prevailing at present. A period drier than the present in the Pleistocene of Tasmania would probably be an interglacial.

Scotchtown Cave

In order to provide limestone for the paper mills at Burnie, a quarry was opened in the Duck River Dolomite on the east side of the Scotchtown Road 3·2 miles south of Smithton. In 1942 a cave was revealed in this quarry with an average depth of two feet of chocolate-coloured cave earth. Bones at the surface were crumbly, but inside the cave earth numerous bones were well preserved. Mr. E. O. G. Scott made a collection of the bones and these are now in the Queen Victoria Museum at Launceston. These are creamy in colour and mineralized.

Scott reported finding giant kangaroos, bandicoots, small birds, *Nototherium tasmanicum, Thylacoleo carnifex, Tachyglossus, Vombatus*, the extinct Tasmanian emu and a reptile. Bones examined by one of us (E.D.G.) at the Queen Victoria Museum included:

- *Nototherium*
- *Thylacoleo* (the first record of this genus from Tasmania; see Gill, 1954*a*)
- *Palorchestes*
- *Sthenurus*
- *Macropus* aff. *titan*
- Wallaby
- *Vombatus*
- *Sarcophilus* (giant form; see Gill 1953*c*)
- *Thylacinus* (large form but within the present size range; see Gill 1953*c*).

In the Queen Victoria Museum there is also a number of boxes of small bones, but there was not time to examine these. The Scotchtown Cave was probably a carnivore's lair.

Pulbeena Swamp

On the east side of Mowbray Swamp is a ridge of ?Cambrian bedrock. East of this ridge (which is half a mile to a mile across) is another swamp called the Pulbeena Swamp. Between Pulbeena Railway Station and the gantry at Fenton's Limestone Quarry on the east side of the railway line north-west of the station, there is a deep drain with floor 205 ft. above S.L. (Aerial Photo Smithton run 6, no. 30,686, 4·3 cm. W. of C.P.), shown on the map in Nye, Finucane and Blake (1934). The drain section reveals.

Surface of ground.	1 ft. 5 ins.	Yellow algal marl with peaty bands.	
	1 ft. 2 ins.	Black peat.	13,520 ± 540 years.
	4 ins.	Whitish marl with numerous shells.	
	10 ins.	Peaty marl.	
Floor of drain.	1 ft. 9 ins.	Whitish marl.	28,190 ± 1,520 years.
Auger hole.	6 ins.	Black peat.	
	2 ft. 0 ins.	Whitish marl.	

"Marl" is used in the sense of Pettijohn (1949). A smell of hydrogen sulphide emanated from the auger hole while it was being worked. On the surface of the spoil heaps consisting of material removed during the making of the drain, a shiny black jet-like substance was noted. Dr. J. A. Dulhunty has informed us that this is due to drying out on the surface and possibly also surface oxidation. "The irreversible changes from the soft-dull to the hard-bright conditions occur when absorbed water is removed from a colloid structure in which the micelles are just touching with contact points. The change is due to plastic deformation of the micelles on release of internal pressure of absorbed water. This produces contact areas instead of contact points between the micelles. The corresponding increase in the cohesive force is such that the micelles cannot be moved apart when water is reabsorbed on wetting. Thus the change is irreversible. If the peat has not reached the critical stage in colloidal development at which the micelles are just touching, then the change does not occur on drying." The same phenomenon was noted on the Mowbray Swamp.

Fenton's Quarry, north-west of Pulbeena Railway Station, reveals 3 to 8 feet of freshwater marl (Aerial photo Smithton run 6, no. 30,686, 4·8 cm. W.N.W. of C.P.). The following succession was determined:

Surface of ground.	1 ft. 0 ins.	Light grey marl with mostly minute shells. Algal remains present.
	8 ins.	Light yellow algal marl.
	2 ins.	Black peat. (?= peat near base of drain section).
Floor of quarry.	2 ft. 0 ins.	Light yellow algal marl to calcilutite, with freshwater gasteropods.
Auger hole.	3 ft. 3 ins.	Continuation of same bed.
	1 ft. 3 ins.	Dark grey peaty sand.
	1 ft. 0 ins.	Light yellowish grey quartz sand with calcareous material.
	6 ins.	Dark grey peaty sand.
	1 ft. 0 ins.	Chocolate brown peaty sand.
Total thickness	10 ft. 10 ins.	

The quarry is L-shaped, extending about four chains in each of the two directions. The beds exposed therein can be traced right round the quarry walls, although with some variation in thickness, e.g., the peat varies from 2 to 6 inches. There are some slight undulations which are probably due to differential compaction but otherwise the strata are horizontal. The amount of sediment from beyond the former lake waters was small, most of the material being of organic origin. The deposits indicate freshwater lacustrine conditions and imply a pluvial period. The vast tonnage of calcic materials in the Mowbray and Pulbeena swamplands has its origin in the underlying dolomite of the bedrock. The Mowbray Swamp deposits were laid down in swamps occupying swales, plus an occasional small lake. The peat is thus much more sandy than at Pulbeena. The Pulbeena Swamp deposits were laid down in a lake and as a result have a much higher percentage of calcic deposits, which are of both animal and plant origin. A detailed study of these deposits is now needed.

Being interested in the occurrence of *Limnicythere* in the moa swamp at Pyramid Valley in the South Island of New Zealand (Duff 1949), N. de B. Hornibrook of the N.Z. Geological Survey requested material for comparison. After restudying Chapman's types from Mowbray Swamp (Hornibrook 1953), samples obtained by us from Mowbray Swamp and Pulbeena Swamp were examined. The only sample providing ostracods satisfactory for his purpose was from Fenton's Quarry which yielded:

Candona lutea King
Ilyodromus stanleyanus (King)
Limnicythere mowbrayensis Chapman

See Hornibrook 1953, 1955.

Samples for radiocarbon analysis were taken from the north wall of the drain just east of the railway line and submitted to Dr. E. S. Deevey. Their C14 ages are:

Peat	2 ft to 2 ft. 7 ins. from surface	13,520 ± 540 years
Marl	5 ft. 6 ins. from surface	28,190 ± 1,520 years.

PLATE V.

FIG. 1.—Entrance to Northern Cave, Rocky Cape, 70 feet above ocean level. The floor of the cave is covered with aboriginal midden.

FIG. 2.—Fish bones from stratified layer of the Southern Cave, Rocky Cape.

FIG. 3.—Bone "awl" made from the fibula of a kangaroo. From fish bone layer, Southern Cave, Rocky Cape.

FIG. 4.—Reverse side of implement shown in fig. 3.

The first date is believed to be the true date, or near it, but the possibility of some contamination by the roots of plants living at the surface after the material concerned was laid down has always to be borne in mind. Such a C14 date is a minimum date. The Pulbeena peat date indicates an early Cary age (cf. Horberg 1955). The second date based on the marl may be affected by the shells and calcareous algae that form the deposit taking up "dead" carbonate from the underlying Precambrian dolomite. Deevey (1954) obtained spurious C14 dates of up to 2,000 years for plants living in a hard water lake. It is quite possible, therefore, that the given age of the marl is greater than that of the peat, partly because of greater antiquity and partly because of incorporation of non-radioactive carbonate from the bedrock. It is hoped later to make radiocarbon analyses of the whole series of alternating peats and marls of the Pulbeena Swamp deposits, thus making it possible to (*a*) compare and contrast the peat and marl calendars and (*b*) determine the rate of formation of the swamp deposits.

Comparison of C14 datings for the Mowbray and Pulbeena Swamps shows that the former is older than the latter. The Mowbray Swamp dates are older than the present range of radiocarbon. The Mowbray Swamp Peat was laid down in swales between sand ridges while the Pulbeena deposits were laid down in a lake. The former were laid down at a time less pluvial than the present, as is shown by the pollen analysis. The latter were laid down in a time as pluvial or wetter than the present. Some difference in age is therefore to be expected.

Rocky Cape Caves

On the east side of Rocky Cape (Aerial photo Smithton run 7, no. 30,627), there are two caves (Stephens 1908, Noetling 1912*b*, p. 103, Crowther 1925, Pulleine 1929, Edwards 1941*a*, Meston 1949), a more northerly one facing west, and a more southerly one facing east. In this paper they will be referred to as the Northern Cave and the Southern Cave respectively. They are cut from ? Precambrian quartzites of high dip (Plate 5, fig. 1), presumably by the sea. The two caves are at similar heights above the sea. A survey was made from the rocky floor at the entrance to the Northern Cave down to the sea, and the floor was found to be 75 feet above low water. Stearns (1935, p. 1939) and many others have provided evidence of a eustatic higher level of the sea of the order of 70 feet above the present level.

HOLOCENE SERIES (late Pleistocene at oldest)

Quarternary Deposits at Mount Cameron West

On the coast, both north and south of Mt. Cameron West, are ancient bays infilled with calcareous sand (Pl. 6, fig. 1) which rests on the Tertiary marine limestone and abuts against the basalt of the "mountain". Our visit was in winter after a storm, so that scour was at a maximum and screening by windblown sand at a minimum. Numerous aboriginal kitchen middens were noted in these sands. The dunes for one and a quarter miles south of Mount Cameron West were searched for the emerged marine shell beds of Quaternary age reported from there (Edwards 1941*a*) but only middens and redeposited midden shells (recognized by being of edible kinds and sizes with some burnt) were found. Shells had been washed from middens by rain and spring waters and redeposited so as to simulate stratified marine shell beds (cf. Gill 1951). It is, of course, possible that emerged marine shell beds occur in this area, but on the occasion of our visit the only beds seen by us of Quaternary age were those described above.

About a mile south of Mt. Cameron West, a section of the dunes exposed by erosion revealed three prominent soil horizons (Plate 6, fig. 2). An aboriginal midden was associated with the lowest, and therefore oldest, of the series of soils. This midden is considered to be historically ancient but geologically recent. The shells in the middens and redeposited beds were chiefly:

Dicathais textiliosa (Lamarck)
Haliotis ruber Leach
Patellanax squamifera (Reeve)
Scutus antipodes Montfort
Subninella undulata (Solander).

These are all molluscs that live on rocks, and so are quite out of character with this sandy environment. The aborigines probably collected them from the basaltic rocks round Mt. Cameron West, and took them to the shelter of the sand dunes to cook and eat them.

On the west side of Mt. Cameron West is a cobble beach which continues up as grassy slopes to a low vertical cliff whose base is of the order of ten feet above present sea-level. At the top of the low cliff is a well-developed terrace cut in the basalt and this is of the order of 25 feet above sea-level. There was not time to make accurate measurements and the tidal range is not known, but these two levels appear to be the work of eustatically higher sea-levels.

The Queen Victoria Museum at Launceston has a large piece of calcareous sandstone from two miles north of Mount Cameron West in which are preserved aboriginal carvings (Meston 1933, Nye 1941, Luckman 1951). Examination of the rock showed it to be an aeolianite (fossil dune rock). Mr. A. C. Collins kindly examined the foraminifera in a sample of this rock and found them to be of Quaternary age. They include *Lagena acuticosta ramulosa* Chapman and *Uvigerina bassensis* Parr, both typical recent Bass Strait forms.

Duck River and Duck Bay

The Duck River flows northward on the eastern margin of Mowbray Swamp, following the edge of the swamp deposits. It has incised its channel 15 to 20 feet. Duck Bay, into which it runs, is shallow with wide sand banks but with muddy sediments in places and rock outcrops on the floor of the bay. A survey chart and aerial photo mosaic kindly lent to us by the Smithton Harbour Trust show that the Duck River channel is only 3½ to 7 feet below M.L.W.S. at Smithton, but between Sampson Point and Perkins Bay the channel suddenly deepens from 8½ to 25 feet. Between Perkins Island and the point opposite, the depth of water reaches 31½ feet and this is on rock, presumably the Duck River Dolomite or perhaps basalt.

The low water datum in Smithton Harbour is the same as that of the Ulverstone tide-gauge, which is about a foot higher than the Devonport gauge. The spring tidal rise in the Harbour is about nine feet. The aerial photo mosaic shows that on Perkins Island and contiguous parts of the coast, the same series of recent sand ridges occurs as is described a little later from the vicinity of the Black River further east. It also shows that a delta, largely of sand (judging from its light colour) has been deposited where the Duck River debouches into Perkins Bay. Both the channel and the sediments are deflected somewhat to the east, as are those of the Black River and Detention River further east. This shows a "set" in Bass Strait towards the east in this area. The Australian Pilot (vol. 2, p. 7) states, "In the bight of the north of Tasmania . . . there is an almost constant current setting eastward during the greater part of the year."

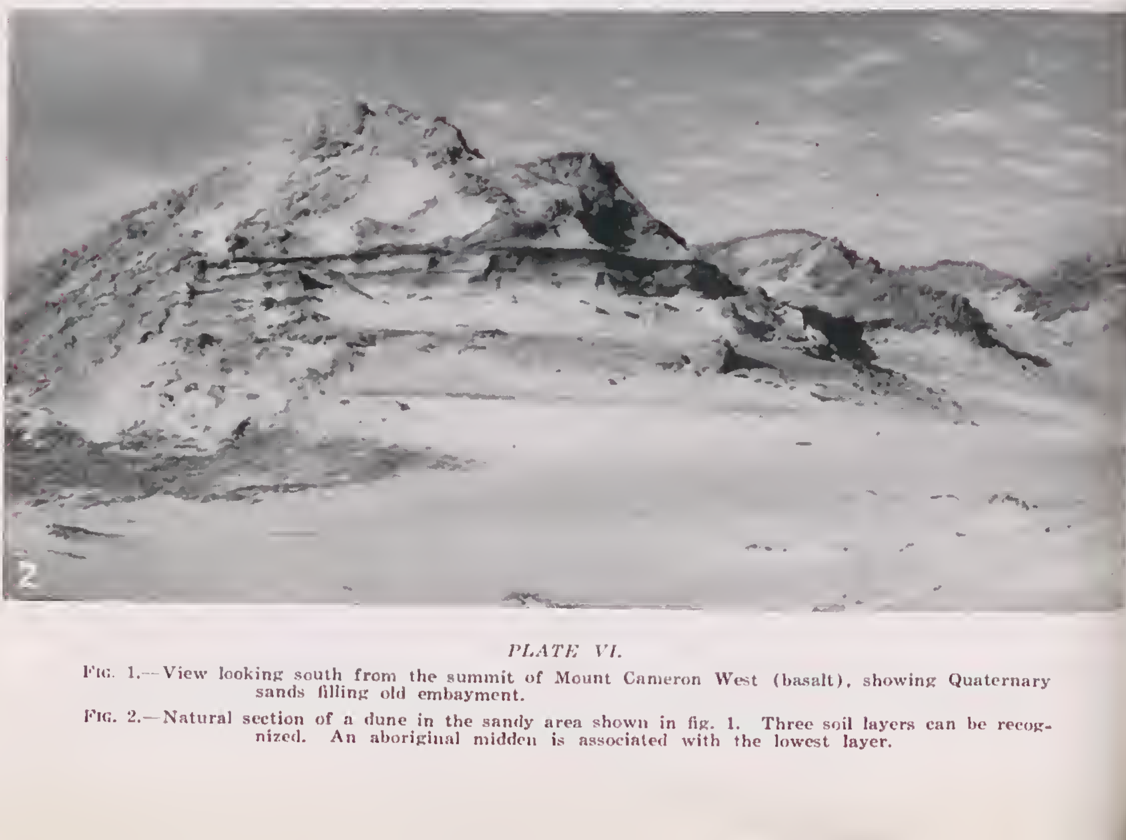


PLATE VI.

FIG. 1.—View looking south from the summit of Mount Cameron West (basalt), showing Quaternary sands filling old embayment.

FIG. 2.—Natural section of a dune in the sandy area shown in fig. 1. Three soil layers can be recognized. An aboriginal midden is associated with the lowest layer.

Holocene Series of Sand Ridges

It is useful to distinguish between coastal *sand dunes* (generally 50 to 100 feet high and perpendicular to the direction of the prevailing winds by which they are built) and *sand ridges* (generally 10 to 20 feet high and following the coast whatever its direction) (Gill 1948, p. 10). The structures now discussed are sand ridges in this sense.

From the aerial photos available (none for the coast in the Smithton area had been taken at the time of the survey), it was noted that the series of sand ridges lining the present coast are well developed between the Bass Highway (which follows their landward margin) and the sea, three quarters of a mile to one and a half miles south-east of the Black River. A survey was made across the sand ridges at right angles to the beach, beginning a little west of the corner on the highway shown on aerial photo 30641, Smithton 7, 3·5 cm. N. of C.P. Behind the sand ridges is a flat swampy area with a small meandering creek which runs into a lagoon near the mouth of the Black River. Behind the swamp is what appears to be an old shoreline, approximately parallel to the present coast. The surveyed section is given in text figure 6 which shows a series of 18 ridges, all of which can be seen to be well developed longitudinally in the aerial photo (Plate 3, fig. 1). The ridges are protected by *Eucalyptus* trees and smaller plants. A good deal of burning off and land clearance has taken place and the sand is beginning to become mobile near the beach. The ridges are comparatively sharp and turn in to the mouth of the Black River. Their physiographic completeness suggests a recent geological age, as also does their relationship to the present coast and the existing river mouth. Only where there is a plentiful supply of sand are the ridges prominent, for they curve off and die out on approach to a rocky shore. In the area studied, their direction varies a good deal, but direction does not vary their character. They are known from other parts of the north coast of Tasmania. Similar well-developed series of recent sand ridges have been described from South Australia (Sprigg 1952) and New South Wales (Burges and Drover 1953).

Although, as one would expect, there is some variation from place to place, three phases of sand ridge building can be recognized in the area studied (see text-figure 6). Sand ridges are built at or near high water and the survey indicates that there has been a fall of sea-level of the order of ten feet. Teichert (1950), Fairbridge (1950) and Gill (1953*a*, 1955*a*) have found evidence in Australia (as others have overseas) of a retreat of the sea from a mid-Holocene level of the order of ten feet above the present. The authors quoted have found indications that this retreat took place in three stages, with stillstands at about five feet and two feet. To equate the three stages of sand ridge building with the three stages of marine retreat is, of course, unwarranted on the slender evidence available, but it may be advantageous to keep the possibility in mind. The ten foot sea level was associated with the postglacial thermal maximum (Gill 1955*a*), which was round about 5,000 years ago. Mehldahl (1950) refers to tidal forces in the sun's corona with a period of 308·52 years. If each sand ridge represents one of these cycles, then the sand ridge series represents 5,553 years. This is another intriguing parallel without any proved connection.

Ancient Series of Sand Ridges

Behind the Holocene series of sand ridges on Perkins Island is a more ancient series whose inland limit is shown in text-figure 4 by the line marked "apparent limit of dunes." They contrast with the recent ridges in that:

1. They are further inland and higher above present sea-level.
2. They are not sharp like the recent ridges, but depressed.
3. They are spaced further apart. Whereas the recent ridges average one for every 25 yards, the ancient ridges average one for every 80 to 100 yards.

   The recent ridges have a ratio of 1 : 3 or 4 with the ancient ridges in size and in frequency per unit distance.
4. There are more of them. Being less distinct, it is difficult to count them precisely, but about 40 can be made out or are suggested by the aerial photos.

Further inland again is a third area typified by the country around Mella, where sand ridges are not readily discerned either on the ground or from the aerial photos but are revealed by excavation or by the natural vegetation. The original vegetation reflected the difference between the sandy ridges and the peaty swales. Mr. F. S. R. Shoobridge of Mella advised us that the sand ridges were occupied chiefly by eucalypts with paperbarks, low tea-tree, a few blackwoods, clematis vines, and heath on the higher parts. The peaty areas were occupied by a dense forest of large paperbarks and blackwoods, a few eucalypts, and myrtle (*Nothofagus*) with low tea-tree and clematis. Mr. H. D. Ingle kindly examined pieces of wood collected by us from the peat of Mowbray Swamp at Mella and recognized them as roots of tea-tree, probably paperbark. They appear to represent the flora growing on the peat after its formation and not the flora forming the peat.

Middens in Rocky Cape Caves

Covering the floor of the Northern Cave and filling adjoining crevices is a copious deposit of charcoal, marine shells and the bones of marsupials, seals, and birds. The site is an aboriginal feasting place. It is said that the natives did not like dark caves, but they apparently appreciated the shelter of open caves such as those at Rocky Cape. Miss Hope Macpherson, Curator of Molluscs at the National Museum of Victoria, kindly determined the molluscs as follows:

Cellana rubraurantiaca (Blainville)
Dicathais textiliosa (Lamarck)
Fasciolaria australasia (Perry)
Floraconus anemone (Lamarck)
Haliotis ruber Leach
Mytilus planulatus Lamarck
Sabia conica Schumacher = *S. australis* (Quoy and Gaimard)
Scutus antipodes Montfort
Subninella undulata (Solander)

The marine shells are similar to those found in the Southern Cave but have a lower percentage of *Subninella* and a higher percentage of *Haliotis*. The bones include those of the Tasmanian Devil (*Sarcophilus*). Seal bones are numerous here but rare in the Southern Cave. As the Northern Cave is nearer the open sea, it is not surprising to find more *Haliotis* and seals in the midden remains.

The Southern Cave has an even greater thickness of midden material in it, determined by Meston (1949) as "just over fifteen feet deep". The midden consists of charcoal, bones, and the following shells:

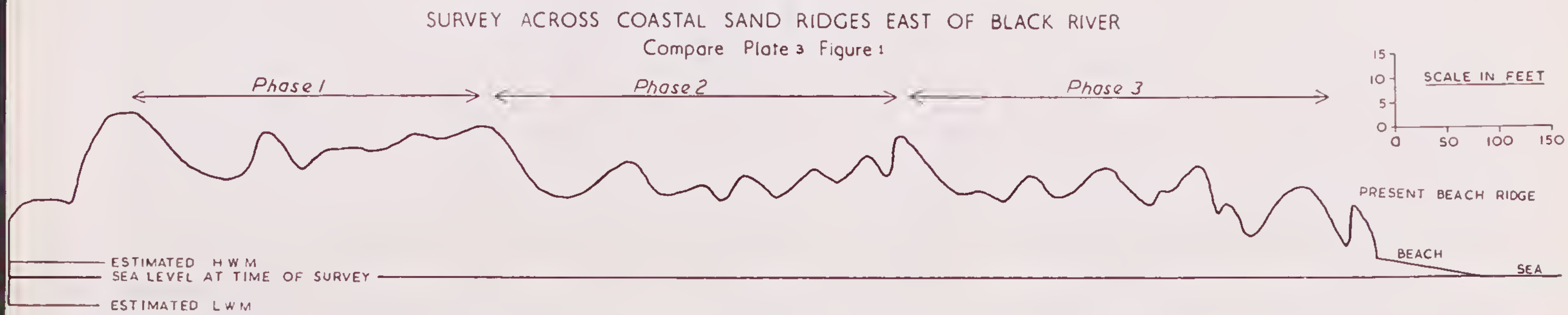

SURVEY ACROSS COASTAL SAND RIDGES EAST OF BLACK RIVER
Compare Plate 3 Figure 1
Phase 1
Phase 2
Phase 3
SCALE IN FEET
15
10
5
0
0
50
100
150
PRESENT BEACH RIDGE
BEACH
SEA
ESTIMATED H W M
SEA LEVEL AT TIME OF SURVEY
ESTIMATED L W M

FIG. 6.

MOLLUSCA

Austrocochlea adelaideae (Philippi)
A. camerata (Wood)
A. obtusa (Dillwyn)
Bembicium nanum (Lamarck)
Cellana rubraurantiaca (Blainville)
Cominella lineolata (Lamarck)
Dicathais textiliosa (Lamarck)
Fasciolaria australasia (Perry)
Haliotis ruber Leach
Mytilus planulatus Lamarck
Ostrea sinuata Lamarck
Poneroplax costata (Blainville)
Sabia conica Schumacher = *S. australis* (Quoy and Gaimard)
Scutus antipodes Montfort
Siphonaria diemenensis Quoy and Gaimard
Subninella undulata (Solander)

BARNACLE

Tetraclita purpurasceus (Wood)

The *Subninella*, *Cellana*, and *Haliotis* are the commonest but the *Dicathais* is also common, while *Scutus* and *Austrocochlea* are not uncommon. The deposit also includes bones of marsupials, birds and fish, numerous quartzite flakes and beach pebbles, which the aborigines probably used as hammer stones.

Fish bones in Midden

Where the midden deposits were undisturbed, some ten feet inside the cave, an excavation was made to a depth of three feet. From 18 inches to 2 feet, a layer was found richer in shells and bones and the latter included numerous bones of the parrot fish (kindly determined by Mr. Gilbert Whitley of the Australian Museum). See plate 5, figure 2. It has been claimed that no Tasmanian aborigines ate fish but this idea seems to rest chiefly on a statement by Captain Cook that the natives refused fish he offered them. West (1852) described an occasion when the Tasmanian aborigines "left their huts . . . in which were fragments of fish, baskets, and spears." Pulleine (1929, p. 147) found a parrot fish jaw at Rocky Cape; and he refers to "what appears to be representations of a fish" in aboriginal carvings (p. 149). Brough Smyth (1878, p. 392) said that the Tasmanian natives of the West Coast "speared sea fish in shallow water." Mr. Whitley said that if they were quick enough they could catch parrot fish by hand amongst the kelp, whence they would seek such molluscs as *Haliotis*. The plentiful fish bones from the Rocky Cape Cave indicate that some Tasmanian natives took fish there, presumably to eat. It could be that some tribes ate fish and some did not. Brough Smyth (1878, p. 393) said, "Certain kinds of food were prohibited, but under what regulations is not known . . . One set would not eat scaled fish." This suggests that some ate fish, while others did not. That natives refused fish offered to them by Captain Cook does not prove that even that group did not eat fish. They may have feared or suspected the strangers, or the fish may have been caught in deeper water and so be species unknown to the natives. That fish bones occur so seldom in Tasmanian coastal middens is also no argument that the Tasmanian natives did not eat fish. Victorian coastal aborigines ate sea fish, but in the hundreds of middens examined by one of us (E.D.G.), in only one were fish bones found, viz., the midden at Armstrong's Bay, Western Victoria (Gill 1951).

Bone Implement

The excavation in the Southern Cave at Rocky Cape also yielded a sharply pointed bone implement, like an awl, manufactured from the fibula of a kangaroo (Plate 5, figs. 3-4). The implement is reg. no. 48,237 in the National Museum of Victoria, and its measurements are as follows:

Greatest length as preserved	5·15 cm.
Greatest width	0·90 cm.
Greatest thickness	0·30 cm.

The markings on the point suggest that it was made by scraping and not by grinding as were so many Australian aboriginal bone implements. Noetling (1912*b*), working with T. Stephens at Rocky Cape, found spatulate ended pieces of fibulae in one of the caves (cf. Crowther 1925) hut he did not believe they were implements. Lord (1926, p. 459) quoted as Captain Cook's account a statement that " one party of natives met with were armed with lances about two feet long, terminating with a shark's tooth or a piece of bone sharpened to a point." As this statement might have a bearing on the implement from Rocky Cape, we asked the Research Section of the Public Library of Victoria under the charge of Mr. P. Garrett to check this quotation. Miss P. Reynolds discovered that this quotation is not from Captain Cook's official log, but from Anderson's (1784) version " written in a more pleasing and elegant Stile ". The official log (Admiralty 1784) referred to " a stick about two feet long and pointed at one end." The embellishment of the bone points appears to have been taken over from the account of the visit to Botany Bay in April-May 1770. So there is no evidence that sharpened bone points were used by the Tasmanian aborigines for tipping weapons. Other bone implements of this kind have been found in Tasmania, and the most likely explanation is that they were used as awls (Meston 1949, p. 149). The natives did not usually wear clothes, hut " when sick covered themselves with a rug made of the skin of the opossum and of the kangaroo. The possum skins were laced together with sinews of the tail of the kangaroo." (Brough Smyth 1878, p. 399). Captain Cook's log (Admiralty 1784) also referred to females who " wore a kangaroo skin (in the same shape as it came from the animal) tied over the shoulders, and round the waist. But its only use seemed to be to support their children when carried on their backs." The manufacture of these items of clothing could be one use for bone awls.

In the Tasmanian Museum in Hobart, there are four Tasmanian aboriginal bone implements, one six inches long, and three eight inches long approximately. They all have spatulate ends. One of us (E.D.G.) found another pointed bone implement in a fissure deposit in limestone at Flowery Gully, north-west of Launceston. This implement is reg. no. 49,246 in the National Museum of Victoria, and its measurements are as follows:

Greatest length as preserved	4·4 cm.
Greatest width	1·35 cm.
Greatest thickness	0·55 cm.

Summary of observations on the Quaternary System

During the Pleistocene the Duck River cut a plains tract above the local base level formed by the rock bar at Perkins Island. Probably the plain was mostly cut in the soluble Duck River Dolomite, and was bounded to the west by low hills of Cambrian? argillite and greywacke, and to the east by steeper hills of dolomite and Cambrian spilite. When the sea rose to the 70-foot level, it flooded this plain and sand was deposited on its floor. As the sea retreated, sand ridges were left on the emerged coastal plain. During a period drier than the present, peat accumulated in the swales between the sand ridges and an open forest association constituted the flora. Giant marsupials inhabited the open glades. Possibly mound springs were already active, producing locally boggy conditions in which some of the animals were trapped. In places ponds and small lakes developed in which freshwater molluscs and ostracods thrived.

Later, in a time of higher rainfall, a lake at Pulbeena supported a rich growth of algae, molluscs and ostracods. In recent times (thought to be mid-Holocene), the sea stood about ten feet higher than at present, producing beaches and shore platforms now emerged. As the sea retreated, sand ridges were formed on Perkins Island, in the vicinity of the Black River, and elsewhere. Sometimes during the Upper Pleistocene or Holocene the Tasmanian aborigines arrived in Tasmania. Carvings and middens occur near Mt. Cameron West, and middens in the caves at Rocky Cape. Evidence occurs in the latter to show that at least some Tasmanian aborigines ate fish, and used bone as well as stone implements.

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ADDENDUM

THE SOILS OF MOWBRAY SWAMP AREA, TASMANIA

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The most important single factor in the genesis of the soils has been the influence of the alkaline spring waters (containing much soluble matter, particularly Ca and Mg) which have been ponded in the swamp and have irrigated the soils, enhancing their nutrient status and preventing the development of extreme acidity.

The main peat type—the granular peat as at Mella—was mapped as being more than 42 in. thick and was generally more than 6 ft. thick. This is a brownish black well-humified eutrophic peat with a deep horizon of brown well-decomposed peat of fine felty structure resting on sands below. A layer of calcareous peaty mud containing small mollusc shells often occurs (at varying depths) in the subsoil. Half a dozen transitional peat soils were recognized, one being a shallow peat over sand, another being a thin clay soil with peat subsoil underlain by sands, and a third a thin peat with peaty clay or clay subsoils.

Two series of fine-textured gley soils are associated with clay sediments—one series occupying shallow depressions occurring principally in the S.W., S. and N. central parts of the swamp while another series occupies a very gently sloping or shelving area along the northern half of its western boundary.

A third series of sandy gleys comprises the dominant soils of the swamp area. The organic-cemented sand "pan" beneath part of these (and some other) soils I interpret as a fossil soil horizon. This may be the B horizon of ground water podzols formed on the sandy plain, following emergence, under conditions of low water-table before the commencement of spring activity, or, more likely, before the influence of the spring waters spread as far as they finally did.

Heath plains composed of sands occur along the margins of the swamp to the north, east and south, and at the same general level as the adjacent swamp soils.

The soils of these plains are:

1. Ground water podzols—a better-drained type on the small sand banks and ridges, and poorly drained, leading to peaty, types on the wetter level to undulating areas.
2. Button grass peats—in depressions.

I G. SHEA, Government Printer, Tasmania.